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ORIGINAL RESEARCH ARTICLE

WATER QUALITY ANALYSIS OF SOME SELECTED HAND-DUG WELLS IN BURUTU COMMUNITY, DELTA STATE

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ABSTRACT

This study investigated the bacteriological and physico-chemical properties of water in selected hand-dug wells in Burutu community, Delta state and compared it with World Health Organisation (WHO) Standard. Water samples from wells in twelve different locations were selected and subjected to filtration prior to chemical analysis. The methods of analyses were determined according to the procedure in APHA. Results obtained show that some of the parameters analyzed were within WHO (2006) guidelines for drinking while others exceeded the threshold. In relation to bacteriological contamination, the result revealed that all the sampled wells were contaminated with total and faecal coliform organisms as they exceeded WHO standard. The sampled wells had a mean of total coliform 175.16±155.73mpn from twelve samples with a range of 67 to 576 mpn. Samples across the wells varied in the range of 67, 86.00, 70 mpn for (Ambar), 110, 360, 294 mpn for (Chicoco), 112, 111, 114mpn for (Low beach) and 102, 576 and 100 mpn for (Okorodudu) quarters respectively. It also shows that none of the wells are of quality in terms of portability for drinking. However, they can be used for other domestic activities like washing of clothes and bathing.

1.0 Introduction

Water as a natural resource is very precious and vital to life, development and the environment. It can also serve as a means for poverty alleviation, lifting people out of degradation, while at the same time bringing prosperity to all (WHO, 2006).

Water is essential for agriculture, drinking, cooling, sanitation, a critical input in industry, for tourism and cultural purposes; and for its role in sustaining the earth's ecosystem (Mark et al., 2002). However, the demand for fresh water for drinking and other domestic use rises continuously as the world's population grows.

Potable water is a fundamental need of man to sustain life. It serves as a lubricant, regulates the body temperature and provides the basis for the body fluids and metabolism (Schafera et al., 2009). Drinking water should be suitable not only for human consumption but also for washing/bathing and household food preparation. It is a well-known fact that when water is polluted, its normal functioning and properties are affected (Trivedi et al., 2010). Continual improvement in the quality of water for purposes of drinking, domestic consumption, personal hygiene and certain medical situations is among the top challenges of the world. Waterborne diseases are the cause of death and suffering of millions of people, especially, children in developing countries (Schafera et al., 2009).

According to the World Bank, only 39% of people that live in cities have improved water source (Yusuf, 2007). This situation has not improved significantly over the past decade. Given such a grim situation, residents are left with no other choice but to seek other sources of freshwater from rainfall, the lagoon and groundwater (by digging wells). The Niger Delta region of Nigeria among any other region in the world faces huge challenges with multiple issues that adversely affect public health such as oil spillage and gas flaring. One major challenge in the region is the ability for both the rural and urban areas to access clean water supply. Estimates suggest that nearly 10 million people in the Niger Delta region of Nigeria lack safe drinking water and at least 3 in every 8 deaths per year are attributed to waterborne diseases, with over 68 percent of the Niger Delta region covered by water. Not only is their poor access to readily accessible drinking water, but even when water is available in these small towns and villages, there are risks of contamination due to several factors. Water quality testing is not performed as often as is necessary, and lack of education among the people utilizing the water source leads them to believe that as long as they are getting water from the creeks, it is safe.

It is against the background of the above that this study aims to determine the physico-chemical parameters, analyse and compare these parameters to WHO maximum acceptable limits, and ascertain the quality and potability of hand-dug wells in Burutu community.

2.0 Materials and Methods

2.1 The Study Area

Burutu Island is an ancient town. It is also the headquarter of Burutu Local Government Area, Delta State Nigeria as shown in the Delta state map below (Fig.1). It is closely bordering the Atlantic Ocean which falls within the Beach Ridges on-shore geomorphic sub-environment of the Niger Delta and lies between latitude 5° 21' 11.81''N and longitude 5° 30' 29.74''E with an elevation of 13m above the sea level (Administrative regions in Nigeria, 2019). The area is characterized by strong wave and tidal action, which further compact the sediments.

The estimated population of Burutu Island in 2006 national census was 98,354. The population of the Island is on the increase as a result of mass influx of people into the area. The rapid growth in population is largely due to the expansion of the oil and allied industries, the Local Government Council Secretariat and Delta State School of Marine Technology that was established in April 2011.

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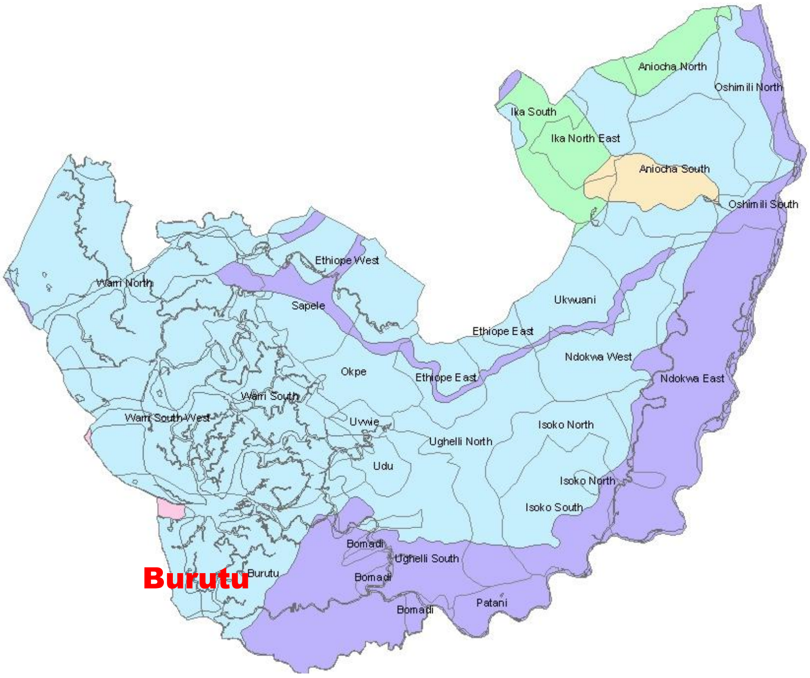

Figure 1: Map of Delta state showing the study location (Delta state government, 2007).

2.2 Water Sampling

Water samples from the selected dug-out wells were collected from twelve locations categorized into four major quarters: Ambar, Chicoco, Low Beach, Okorodudu that makes up Burutu Island. A total of twelve dug-out wells were sampled.

In order to obtain accurate results, proper sampling procedures were adopted to eliminate or minimise potential contamination of the samples. Sample containers were soaked in nitric acid (NHO3) overnight and washed with distilled water, rinsed with deionised water and dried in a drying cabinet. Sample containers were clearly labelled to enhance record keeping. An analysis was done approximately 72hrs after sampling.

2.3 Analyses for Physico-chemical Parameters

The samples were analyzed for major physical and chemical water quality parameters namely pH, total dissolved solid (TDS), total suspended solids (TSS), total hardness (TH), chlorides, sulphate, nitrates, magnesium, calcium, manganese, copper, zinc, iron and lead. Samples were subjected to filtration prior to chemical analysis. The methods of analyses were determined according to the procedure in APHA.

The pH of the water samples was obtained pH meter (Model pHS-25, Rex Instrument Factory Shanghai).

Electrical conductivity of the water samples was measured using the battery operated conductivity bridge (Model MC-1 MarkV Electronic Switchgear).

Total dissolved solid was determined according to the procedure and protocols outlined in APHA (1998). Whatman filter paper and 250ml conical flask was oven dry at 50oC for 3 hours, cool in a dessicator and weighed. 100ml was filtered exactly through the filter paper into the conical flask. The water evaporated to dryness on a hot plate and the filter paper was dried in the oven set at 50°C until a constant weight was obtained for each. The weight of the filter paper and flask were recorded separately. The difference between the weights obtained from the total solids and total dissolved solids for each sample gave the value of the total suspended solids content in mg/l of the sample.

The colour of the samples was determined using a Nessleriser. Standard disc NSA was also used for comparison. The value of colour was read directly in Hazen units on the platinum-cobalt scale.

Nitrate was determined by the colorimetric methods using phenoldisulphonic acid as described in APHA, (1998). 50ml of samples was put in a porcelain dish and evaporated at 1080C in a Gallenkamp water bath. The dry residue was then dissolved by adding 2ml of phenoldisulphonic acid, followed by 20ml of distilled water and 7ml of concentrated ammonia solution until a maximum yellow colour developed. The absorbance was then read at a wavelength of 410nm using the Milton Roy Spectronic 21D spectrophotometer.

Chloride was determined by MOHR's method as described in APHA, (1998). This method employs silver nitrate as titrant and potassium chromate as the end point indicator. The chloride ion present in the samples is precipitated as white sliver chloride. Firstly, a reddish-brown colour comparison blank was prepared by adding 1ml potassium chromate and then 0.2ml 0.02M silver nitrate solution to 100ml distilled water in a clean conical flask. It was shaken gently and left to stand. 100ml of sample was put into a conical flask with the aid of a pipette followed by 1.0ml of potassium chromate indicator and titrated, with constant stirring, with 0.02M silver nitrate to the colour of the comparison blank. The value of chloride ion concentration was obtained by Equation (1).

$$\text{Cl (mgl-1)} = \frac{(A-B)\times M\times 70{,}900}{ml of sample} \quad (1)$$

where:

A = ml silver nitrate used for titrating sample

B = 0.2ml silver nitrate used for titrating blank

M = morality of silver nitrate

2.4 Measurement of Sulphate in Water

This was determined by the turbidimetric method as described in APHA, (1998). This method involves a mixture of sodium chloride-hydrochloric acid (dissolve 60g NaCl in water add 5ml concentrated HCL), barium chloride, glycerol-ethanol solutions. 100ml of sample was measured into a 250ml conical flask, followed by 5ml conditioning reagent and mixed in a stirring apparatus while 20ml of NaCl-HCL solution, 20ml glycerol-ethanol, and 0.3g of barium chloride was added and stirred for 2 minutes. The mixture was immediately poured into absorption cell and measure using the absorbance at 420nm after 3 minutes. The reading from the spectrophotometer was compared with the blank.

2.5 Total Hardness

Twenty-five (25) ml of the well-mixed water sample was measured into a conical flask. Two (2) ml of buffer solution and a pinch of Eriochrome black were added. When the sample turned into wine red in color, magnesium and calcium was present. The solution was titrated against 0.01 M EDTA until the wine red color turned to blue. A blank titration was also carried using distilled water as recommended by APHA (1998).

Calculation: Total hardness = $\frac{(A-B)\times 1000}{C}$ (2)

Where; A = volume of EDTA consumed for sample (ml), B = volume of EDTA consumed for blank (ml) and C is the volume of the water sample (ml).

2.6 Total coliform bacteria

Total coliform and faecal coliform were enumerated by multiple tube fermentation tests as described by APHA (1998). Coliform count was obtained using the three tube assay of the Most Probable Number (MPN) technique. Presumptive coliform test was carried out using MacConkey broth (Oxoid). The first set of the five tubes had sterile 10ml double strength broth and the second and third sets had 10ml single strength broth. All the tubes contained Durham tube before sterilization. The three sets of the tubes received 10ml, 1ml and 0.1ml of water samples using sterile pipettes. They were carefully labeled and incubated at 37ºC for 24-48 hours for estimation of total coliform. Acid production was determined by colour change in the broth from reddish purple to yellow and gas production was checked for by entrapment of gas in the Durham tube. The MPN was then determined from the MPN table for the three set of tube.

3.0 Results and Discussion

Table 1 presents the physico-chemical and bacteriological analysis of water samples collected from residential hand hug wells in Burutu Community, Delta State. Results of physical-chemical and bacteriological analyses (mean ± standard deviation, minimum, median, maximum values) are indicated in Table 2. The results show that the colour of water samples collected were found to range from 5.0-15 pt/Co with a mean and standard deviation value 7.5±3.371 pt/Co. The lowest value of 5 was observed in wells 1, 2, 3, 4, 7, 9 and 12 pt/Co, while the highest value 15 pt/Co was observed in well 11 of Okorodudu quarter (Table 1).

Table 1: Physicochemical and Bacteriological Parameters of hand dug wells

	Ambar Burutu			Chicoco			Low Beach			Okorodudu		
Parameters	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Well 12
Colour	5	5	5	5	10	10	5	10	5	10	15	5
pH	5.83	5.10	4.80	5.16	5.66	5.69	4.52	4.45	4.43	5.68	5.8	5.73
EC (µS)	200	150	460	500	490	670	230	400	250	670	270	170
TDS (mg/l)	130	100.00	300.00	330	320	420	140	260	160	420	180	80
TSS (mg/l)	1.05	1.05	1.05	1.05	12.60	12.85	1.25	14.50	0.00	16.50	15.05	1.05
TH (mg/l)	46.97	14.40	113.19	86.24	45.43	61.60	23.87	61.60	56.21	83.16	96.25	16.17
Chloride (mg/l)	29	7.0	48	76	87	87	44	52	34	171	73	10
Sulphate (mg/l)	20	6	40	150	25	30	40	200	40	200	20	21
Nitrate (mg/l)	2.02	0.50	2.53	5.05	6.10	6.50	2.10	2.80	2.06	12.20	4.85	0.85
Mg (mg/l)	8.45	4.94	46.05	16.65	14.85	12.95	5.25	11.25	12.85	20.85	18.16	6.25
Ca (mg/l)	36.47	8.64	85.95	68.85	28.95	46.70	17.66	48.64	39.06	59.86	76.84	8.96
Manganese (mg/l)	0.082	0.000	0.210	0.205	0.213	0.478	0.000	0.000	0.000	0.050	0.135	0.010
Cu (mg/l)	0.137	0.080	0.285	0.048	0.041	0.053	0.015	0.025	0.069	0.000	0.013	0.000
Zn (mg/l)	0.342	3.190	3.285	5.120	0.000	6.680	1.025	1.127	5.589	0.000	0.024	0.000
Fe (mg/l)	0.420	0.837	0.865	0.900	0.874	0.921	0.163	0.245	0.311	0.343	1.799	0.068

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Table 2: Mean values of Physico-chemical and Bacteriological parameters of hand dug wells

Parameters	N	Minimum	Maximum	Mean	Std. deviation	WHO
Colour (pt/Co)	12	5.0	15	7.5	3.371	15
pH	12	4.43	5.83	5.24	0.563	6.5-8.5
EC (µS)	12	150	670	371.66	186.24	1000
TDS (mg/l)	12	80	420	236.66	120.78	500
TSS (mg/l)	12	0.0	16.50	6.50	6.96	400
TH (mg/l)	12	14.40	113.19	59.83	31.70	NA
Chloride (mg/l)	12	7.0	171.0	59.83	44.32	250
Sulphate (mg/l)	12	6	200	66	72.51	250
Nitrate (mg/l)	12	0.5	12.2	3.96	3.25	10
Mg (mg/l)	12	4.94	46.05	14.87	11.08	0.20
Ca (mg/l)	12	8.64	85.95	43.88	25.61	75
Manganese (mg/l)	12	0.0	0.478	0.12	0.144	NA
Cu (mg/l)	12	0.0	0.285	0.06	0.07	NA
Zn (mg/l)	12	0.0	6.68	2.19	2.47	5.0
Fe (mg/l)	12	0.068	1.799	0.65	0.48	0.3
Pb (mg/l)	12	0.0	0.0	0.00	0.00	0.01
TC Count (cfu/100ml)	12	67	576	175.16	155.73	0
TF Coliform (cfu/100ml)	12	18	282	58.42	76.33	0
TB Count (cfu/100ml)	12	169	1218	436.41	106.68	0

The pH of all the sampled wells had a pH lower than WHO (2006) guideline for drinking water. Ambar, Chicoco, Low Beach and Okorodudu are situated along and/or close to Akewa group of company, NPA, Burutu Local Government industrial plant house and Delta State School of Marine Technology industrial workshop, hence the lower mean pH values can be attributed to industrial emission. One major attribute resulting to low pH is that the community is situated in an island that is surrounded by the ocean; hence salt water from the creek may have altered the acid-base equilibrium of the surrounding water table.

Out of all the well water sources sampled, samples from Ambar, Chicoco, Low Beach and Okorodudu quarters showed light and dark brown colour with a range of 5 to 15 (pt/Co) across the wells. The source of the samples was open well where water table was 8 ft deep. The surrounding possible contamination sources found were decayed plants since Burutu was land filled (dredging). Thus the colour of the sample may be due to suspended minerals and dead organic matter.

In this study, Electrical conductivity (EC) value in samples from Ambar quarter ranged from 150 to 460 µS/cm across the wells, 490 – 670 µS/cm in samples from Chicoco quarter, 230 to 400 µS/cm for Low Beach quarter and 170 – 670 µS/cm in well samples from Okorodudu. However, the high mean conductivity of samples from Chicoco quarter can be adduced to high amount of dissolved ions resulting from industrial activities in that area. The electrical conductivity values were within the standards for drinking water quality (WHO, 2006).

The TDS values of sampled wells across the quarters varied in the range of 80 to 420 mg/l, the lowest being observed in well sample number 10, while the highest was in well samples number 6 and 10. This range is similar to the one obtained by Nnaji and Omotugba (2014). The most remarkable observation of this study was the alarmingly high level of total dissolved solids (TDS) in well samples number 6 and 10. Samples from Okorodudu quarter wells were collected from domestic tube wells and metal drums having age of 5-10 years and water table of 8 ft. The surrounding sewage line and gutter were located at about 15-22 ft away. On overall basis, it is evident that the underground strata contain high concentration of easily soluble salts, which may be the main cause of high TDS value across the quarter's well water samples. However, the level of TDS recorded in the samples is an indicator of potential concern and warrant further investigation.

The TSS values of water from Ambar, Chicoco, Low beach and Okorodudu varied in the range of 1.05 mg/l, 1.05– 12.85, 0.00 – 14.50 and 1.05 to 16.50 mg/l respectively. The relatively high TSS mean for samples from Okorodudu quarter indicates high concentration of bacteria, nutrients and metals in the water. The mean values of TSS recorded for samples from Okorodudu quarter were much higher than that of Ambar and Low beach samples. Also, the high TSS values recorded across the sampled wells except sample number 9 indicates bad taste, high water hardness and could also result in laxative effect. The relative high levels of TSS in well water are not acceptable due to the resulting taste. Water with very low concentrations of solids is also unacceptable to consumers because of its insipid taste, often resulting to corrosion of water supply systems (Srinivasa and Venkateswarlu,1999).

The total hardness values of the samples were found in the range of 14.40 to 113.19 mg/l. Samples from Ambar, Chicoco, Low beach and Okorodudu quarters varied in the range of 14.40 to 113.19, 45.43 to 86.24, 23.87 to 61.60 and 16.17 to 96.25 mg/l respectively. The relatively high mean of total hardness recorded for samples from Ambar quarter may be due to run-off that carried dissolved calcium and magnesium ions into the wells as some of them are not properly protected with concrete. The means of total hardness across the sampled wells may be due to dissolution of ions by rainwater percolation in the soil. The ions may have originated from run-offs that infiltrated into the soil causing leaching. The values of total hardness recorded from the samples also indicated that Burutu land is rich in calcareous and carbonaceous minerals. These results clearly revealed that total hardness value of the sampled wells is above the threshold of WHO standards and could be harmful to the local inhabitants.

The concentration of chloride across the samples varied in the range of 7.0 for well sample number 2 to 171 mg/l for sample number 11. Cl- content values varied from 7.0 to 48 mg/l in Ambar quarter, 76 to 87 mg/l in Chicoco, 34 to 52 mg/l in Low beach and 10 to 171 mg/l in Okorodudu quarter respectively. This relative mean value of chloride recorded may be attributed to seawater intrusion. The high values of chloride in the water samples may be due to the aquifer which is prone to seawater in the coastal area. Thus, the high value of chloride of the sampled well water can increase the electrical conductivity of the water and also increases its corrosivity. However, the results indicate that chloride content in the water sources were within the acceptable limit of 250 mg/l (WHO, 2006). Mean values of 20, 6 and 40 mg/l for Ambar, 150, 25 and 30 mg/l for Chicoco, 40, 200 and 40 mg/l for Low beach and 200, 20 and 21 mg/l for Okorodudu were recorded for the sampled wells respectively. Although, samples from well numbers 8 and 10 had the highest values; these values are lower than the 250 mg/l of WHO (2006) permissible standard for drinking water quality.

The relative high values of sulphate recorded in some of the wells could be traced to the geology of the soil. The values recorded for well samples number 8 and 10, suggests a likely characteristic taste of somewhat bitter. Based on the results, sulphate level is not likely to cause health hazard. The result revealed that the lowest nitrate value was recorded in well sample 2 (0.50 mg/l) and the highest value of 12.20 mg/l in surface well sample 10. The nitrate values of the different sampled wells in Ambar quarter were found to be below the permissible limit of WHO (2006) for drinking water. The values of nitrate obtained in samples from Chicoco quarter varied between 5.05 to 6.50 mg/l which was also below the drinking water standard of WHO (2006) but higher than values obtained from Ambar quarters. The higher nitrate values recorded for these samples may be a reflection of the organic material loads that settled at the bottom of the wells.

Mg values in all the sampled wells varied in the range of 11.08 to 14.87mg/l, the lowest being observed in well sample 2 and highest in well sample 10. Mg values of water from Ambar, Chicoco, Low beach and Okorodudu quarters varied in the range of 8.45, 4.94, 46.05, 16.65, 14.85, 12.95, 5.25, 11.25, 12.85, 20.85, 18.16 and 6.25 mg/l respectively. These values were found to be within the 150 mg/l WHO (2006) guideline for drinking water. The relative mean values of magnesium recorded across the samples may be due to seawater intrusion since the water table is very high, dissolved minerals and run-offs contaminated with magnesium. The values of magnesium recorded may also be attributed to the geological locations of the area.

The concentration of calcium ranges from 8.64 to 85.95 mg/l for Ambar sampled wells, 28.95 to 68.85 mg/l for Chicoco sampled wells, 17.66 to 48.64 mg/l for Low beach sampled wells and 8.96 to 76.84 mg/l for Okorodudu sampled wells respectively. The relatively high values of calcium recorded across the samples except well number 2 and 12 may be attributed to the various construction materials, such as cement, brick lime and concrete sued for the well as well as the geological conditions of the area. Also, the values recorded may be attributed to seawater intrusion and run-offs containing dissolved minerals. However, these values were within the WHO (2006) guideline for drinking water.

The average zinc concentration in seawater is 0.6 – 5 ppb. Zinc concentration in the analysed water samples were 0.342, 3.190 and 3.285 mg/l for samples 1 to 3 (Ambar), 5.120, 0.000 and 6.680 mg/l for samples 4 to 6 (Chicoco), 1.025, 0.000 and 6.680 mg/l for samples 7 to 9 (Low beach) and 0.000, 0.024 and 0.000 mg/l for samples 10 to 12 (Okorodudu) quarters respectively. Some of these values were within 5.0 mg/l acceptable limit of WHO (2006) except well samples number 4, 6 and 9 which had mean value that exceeded the standard. The relatively high values of zinc recorded in some of the sampled wells may be attributed to point and non-point sources of pollution. The variations in zinc values across the sampled wells maybe adduced to poor environmental hygiene.

The observed mean Fe concentrations were in the order of well 1<well 2<well 3 (Ambar quarter), well 5<well 4<well 6 (Chicoco quarter), well 7<well 8<well 9 (Low beach quarter) and well

12<well 10<well 11 (Okorodudu quarter) respectively. Samples from Ambar quarter had mean Fe concentrations that were above the WHO (2006) standard value of 0.3 mg/L while the mean values for samples from Chicoco quarter still exceeded the standard. In addition, the mean values for samples from Low beach and Okorodudu quarters exceeded the standard guideline except well samples number 7 and 12 which was within the standard. The high iron concentrations recorded in majority of the sampled wells suggest dissolved iron by rainwater from soil particles into the ground water. The relatively high iron concentration values may also be adduced to run-offs that carried sediments containing iron particles. The high concentration of iron recorded in the samples is validated by the level of pH and total hardness of the water samples recorded. Samples across the four quarters had mean iron concentrations that were above the acceptable level except well sample 7 and 12.

In comparison of the sampled wells in terms of lead variations is shown in Table 2. The values of lead recorded were below detectable limit of WHO (2006) standard for drinking water.

The bacteriological results showed that all the sampled wells were contaminated with total and faecal coliform organisms because they exceeded WHO standard of 10MPN/100ml and 0MPN/100ml respectively. The sampled wells had a mean of total coliform 175.16±155.73mpn from twelve samples with a range of 67 to 576 mpn. Samples across the wells varied in the range of 67, 86.00, 70 mpn for (Ambar), 110, 360, 294 mpn for (Chicoco), 112, 111, 114 mpn for (Low beach) and 102, 576 and 100 mpn for (Okorodudu) quarters respectively. This indicates that bacteriologically, none of the sampled wells are fit for drinking. This result corroborates the finding of Olobaniyi and Efe (2007) that the MPN coliform index per 100ml of water samples collected from selected areas in the oil producing region of Nigeria had 23 to 45 MPN/100ml.

Conclusion

From the results, some of the parameters analysed were within WHO (2006) guideline for drinking while others exceeded the threshold. In relation to bacteriological contamination, the result revealed that all the sampled wells were contaminated with total and faecal coliform organisms as they exceeded WHO standard of 10MPN/100ml and 0MPN/100ml respectively. It also shows that none of the wells are of quality in terms of portability for drinking. However, they can be used for other domestic activities like washing of clothes and bathing.

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